Amendments to the Specification:

Please replace paragraph 3 with the following rewritten paragraph:

Traffic signals should appear bright over a wide range of viewing angles. In the past, the use of light emitting diodes (~~LED's~~ LEDs) for such applications has been limited due to the high degree of directionality of the LED light source which restricts the effective viewing angle to angles relatively near to normal incidence. The prior art discloses use of an external lens to spread the LED light and increase the effective viewing angle. Because of the large amount of light refraction required to convert the highly directional LED light output to a more uniform beam output, conventional thick lenses are not appropriate. Instead, the prior art discloses using Fresnel lenses for this purpose. However, the use of Fresnel lenses for LED traffic signal lights has the disadvantage of typically reducing system efficiency by at least ten percent due to Fresnel losses in the lens.

Please replace paragraph 5 with the following rewritten paragraph:

In accordance with one embodiment of the present invention, a lighting apparatus is disclosed. A wave guide has microstructures arranged on a surface thereof. The microstructures interact with light in the wave guide to scatter at least a portion of the light out of the wave guide in a pattern. The pattern is determined by the arrangement of the microstructures. A plurality of light emitting diodes ~~are~~ is coupled to the wave guide and ~~inject~~ injects light into the wave guide.

Please replace paragraph 11 with the following rewritten paragraph:

In accordance with another aspect of the present invention, the wave guide defines a planar region. The plurality of light emitting diodes ~~are~~ is arranged around at least a portion of a perimeter of the planar region and ~~inject~~ injects light into the planar region of the wave guide.

Received from < 216 241 1666 > at 11/7/03 10:11:06 AM [Eastern Standard Time]

Please replace paragraph 15 with the following rewritten paragraph:

In accordance with another embodiment of the present invention, an optical wave guide for use in conjunction with an associated light source is disclosed. A translucent material is formed into a shape having a top surface, a non-parallel bottom surface, and at least one side surface in optical communication with the associated light source. A plurality of microstructures ~~are~~ is disposed about the bottom surface. The plurality of microstructures ~~cooperate~~ cooperates with the bottom surface to scatter at least a portion of light injected from the associated light source. The scattered light exits the wave guide through the top surface.

Please replace paragraph 17 with the following rewritten paragraph:

In accordance with another aspect of the present invention, the plurality of microstructures ~~include~~ includes a surface roughness or texture formed into the bottom surface.

Please replace paragraph 30 with the following rewritten paragraph:

With reference to FIGURE 1, a first embodiment of the invention is described. A lighting apparatus **10** includes a substrate **12** which is essentially planar. An optical wave guide **14**, also essentially planar, is formed from a translucent material and is affixed to the substrate **12** using an adhesive, fasteners, or other means (not shown). The essentially planar optical wave guide **14** can be of any geometric shape, such as a circle, an oval, or a rectangle. In FIGURE 1 the wave guide **14** is shown as a rectangle with rounded corners. A plurality of light emitting diodes (~~LED's~~ LEDs) **16** ~~are~~ is mounted on the substrate **12** and ~~surround~~ surrounds the perimeter **18** of the wave guide **14**. The ~~LED's~~ LEDs **16** are mounted approximately at right-angles to the essentially planar wave guide **14** so that light generated by the ~~LED's~~ LEDs **16** is injected into the wave guide **14**. A refractive index-matching material **20** advantageously is disposed between the wave guide **14** and the ~~LED's~~ LEDs **16**.

The index matching material 20 optionally also serves as an encapsulant for the ~~LED's~~ LEDs 16, so that a sealed unitary structure comprising the wave guide 14 and the plurality of ~~LED's~~ LEDs 16 is formed. Such a sealed unitary structure is advantageously essentially weatherproof and can be manufactured and utilized without external containment or lenses. The top surface of the wave guide 14, or a selected portion thereof, can be directly exposed without a lens or other covering. The lighting apparatus 10 also preferably includes an opaque coating or covering (not shown) that blocks the ~~LED's~~ LEDs 16 from being directly viewed.

Please replace paragraph 32 with the following rewritten paragraph:

With continuing reference to FIGURE 1, further reference is now made to FIGURE 2, which shows a sectional view of the lighting apparatus 10 taken along the Section S-S indicated in FIGURE 1. The wave guide 14 includes an essentially planar light-emissive face or top surface 30, a bottom surface 32 that has a pre-defined slope or curvature, and at least one side surface 34. In the illustrated embodiment, the side surface follows the perimeter 18 of the wave guide 14, around which the ~~LED's~~ LEDs 16 are arranged. In the embodiment shown in FIGURE 2, the pre-defined curvature of the bottom surface 32 of the wave guide 14 includes a surface tilt of angle ϕ with respect to the plane of the wave guide 14, i.e. with respect to the essentially planar substrate 12. Other curvatures, such as parabolic or discontinuous (e.g., stepped) curvatures, are also contemplated for the curvature of the bottom surface 32. The bottom surface 32 also includes a plurality of microstructures 36 disposed on selected areas of the inside of the bottom surface 32.

Please replace paragraph 33 with the following rewritten paragraph:

In operation, light 38 generated by the ~~LED's~~ LEDs 16 is coupled or injected into the at least one side surface 34 substantially along an axis 40 which lies at a right angle to the top surface or emissive face 30. The optical coupling is enhanced by the refractive index-matching material 20 that reduces reflection losses at the side surface 34. The injected light

38 is advantageously confined within the wave guide 14 by total internal reflection as is well known to those skilled in the art. However, the microstructures 36 that are disposed on selected areas of the bottom surface 32 act as scattering centers that scatter the guided light 38. At least a portion of the injected light 38 is converted into scattered light 42 through interaction with the microstructures 36 on the bottom surface 32, and at least a portion of the scattered light 42 is scattered toward the top light-emissive surface 30 of the wave guide 14. That portion of the scattered light 42 that encounters the top surface 30 at an angle (respective to the surface normal of the top surface 30) that is less than the critical angle for total internal reflection at the surface 30 exits the wave guide 14 through the top surface 30 as the visible light emission of the lighting apparatus 10.

Please replace paragraph 35 with the following rewritten paragraph:

With continuing reference to FIGURES 1 and 2, in one embodiment the plurality of microstructures 36 ~~are~~ is arranged on selected areas of the bottom surface 32. In FIGURE 1, the microstructures 36 are arranged to display a combination of symbols 50 corresponding to the word "WALK". Thus, the embodiment of FIGURE 1 is suitable for a pedestrian "WALK" signal. Because the light 38 is scattered only off the selected areas that are covered by the microstructures 36, the arrangement of microstructures 36 shown in FIGURE 1 that forms the symbol combination "WALK" 50 produces a corresponding light output pattern of the lighting apparatus 10 that appears to an associated viewer as "WALK". Because the scattered light 42 is viewed, rather than the direct LED radiation 38, the text is readable at large viewing angles.

Please replace paragraph 37 with the following rewritten paragraph:

With reference now to FIGURE 3, another embodiment 110 of the lighting apparatus is described. Rather than defining a selected symbol or combination of symbols, in the embodiment of FIGURE 110 the plurality of microstructures 36 ~~are~~ is uniformly distributed across the bottom surface of a circular wave guide 114 to form a uniform light output beam by wave guide mixing that is viewable at large angles. Th color produced by the lighting

apparatus **110** can be established by using selected ~~LED's~~ LEDs **116** that emit light of the selected color, e.g. red, yellow, or green ~~LED's~~ LEDs. In another embodiment, the ~~LED's~~ LEDs **116** are white ~~LED's~~ LEDs and the wave guide **114** is appropriately tinted to produce a selected color. The latter variant has the benefit of using standardized white ~~LED's~~ LEDs **116** throughout.

Please replace paragraph 41 with the following rewritten paragraph:

Although the invention has been described with particular reference to traffic signal applications, it will be appreciated by those of ordinary skill in the art that the invention is not so limited, but rather will also find application in general illumination, such as in desk lamps and illuminated magnifying glasses, where spatially and angularly uniform light output is desirable. For example, the lighting apparatus embodiment **110** of FIGURE 3 is suitable as the light source for a desk lamp, for room illumination, and the like. In an alternate embodiment, the invention will find application in light mixing applications. Considering again the embodiment **110** of FIGURE 3, the plurality of ~~LED's~~ LEDs **116** can optionally include two or more different types of ~~LED's~~ LEDs, e.g. a sub-set of blue ~~LED's~~ LEDs and a sub-set of yellow ~~LED's~~ LEDs (not shown). By selectively operating one or the other sub-set of ~~LED's~~ LEDs, the lighting apparatus so modified can produce either blue light or yellow light. Additionally, by operating both the blue sub-set and the yellow sub-set of ~~LED's~~ LEDs simultaneously, the wave guide **114** serves as a light mixing component and green light (the color combination resulting from mixing blue and yellow light) is produced. Using this approach, the three red, yellow, and green signal lights of a conventional traffic control signal can be effectuated by a single lighting apparatus (not shown) having red, yellow, and green sub-sets of ~~LED's~~ LEDs, thus enabling a more compact traffic control signal light. Of course, such color combinations and light mixing can also be applied to symbolic lights such as the lighting apparatus **10** shown in FIGURE 1. For example, the "WALK" signal light of FIGURE 1 could be modified to include a white lighting condition for the initial portion of the walk cycle, followed by a reddish lighting condition that signifies that the end of the cycle

is nearing. Of course, the ~~LED's~~ LEDs can also be blinked on-and-off or otherwise intensity-modulated to provide an indication of the nearness of the end of cycle.